MECHANISMS CONTROLLING THE AIR-SEA EXCHANGES OF CO2 IN THE EUTROPHICATED COASTAL WATERS OF THE SOUTHERN BIGHT OF THE NORTH SEA: A MODELLING STUDY

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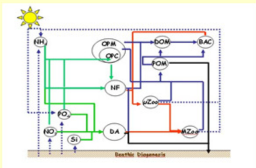
OUTLINE

A CO2 chemical module has been coupled to the complex biogeochemical model MIRO (Lancelot et al., 2004) to describe the seasonal cycle of air-to-sea exchanges of CO2 in the *Phaeocystis*-dominated coastal waters of the Southern Bight of the North Sea. Model results were obtained by running the model for the 1996-1999 period. The predicted pCO2 were compared with data recorded over the same period at station 330 (51°26.05 N; 002°48.50 E). On an annual basis we calculated for the coastal area a CO2 sink of 0.5 molC m-2. We further explore the contribution of biological, chemical and physical processes to the observed seasonal pCO2 variability by running scenarios with separate closure of biology and river inputs.

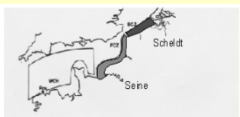
MODEL DESCRIPTION & IMPLEMENTATION



The MIRO model describes the dynamics of phytoplankton (diatom, flagellates, *Phaeocystis*), micro- and meso-zooplankton, dissolved and particulate organic matter degradation and nutrients regeneration in the water column and the sediment (Lancelot et al., 2004).

The physico-chemical module of Hannon *et al.* (2001) was added to describe the carbonate system in seawater and air-sea exchange of CO2. The speciation of the carbonate system is calculated from the knowledge of only DIC and TA, using stoichiometric relationships and apparent equilibrium constants, which are complex functions of temperature, pressure and salinity (Millero *et al.*, 1993)

MIRO-CO2 is implemented in a multi-box frame delineated on the basis of the hydrological regime and river inputs. In order to take into account the cumulated nutrient enrichment of Atlantic waters by the Seine and Scheldt rivers, the model is run for successively



1) The Western Channel (WCH)
2) The French coastal zone (FCZ) with the Seine discharge and input from WCH
3) The Belgian coastal zone (BCZ) with the Scheldt discharge and input from FCZ

Each region is characterized by its own area, depth, water temperature and light conditions

DATA SETS

Biological and nutrient data: Lancelot et al., 2004

CO2 data sets: http://www.ulg.ac.be/oceanbio/CO2/

Wind speed: Koninlijk Nederlands Meteorologisch Instituut (KNMI).

ACKNOWLEDGEMENT

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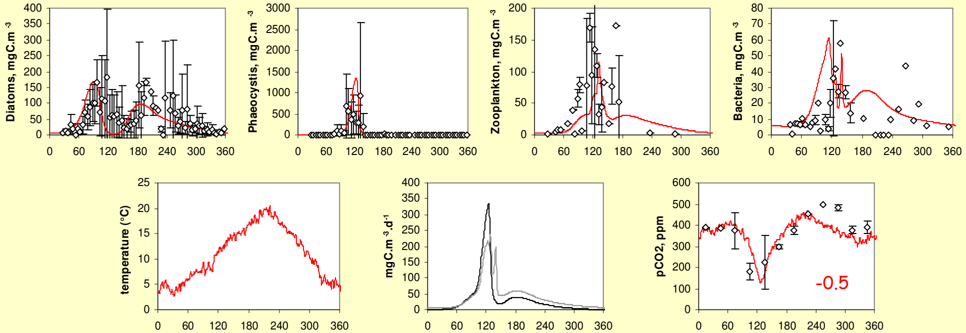
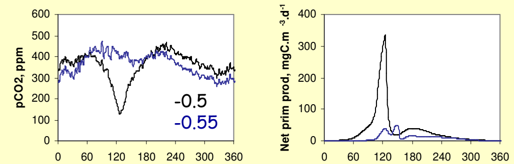
MODEL RESULTS

VALIDATION



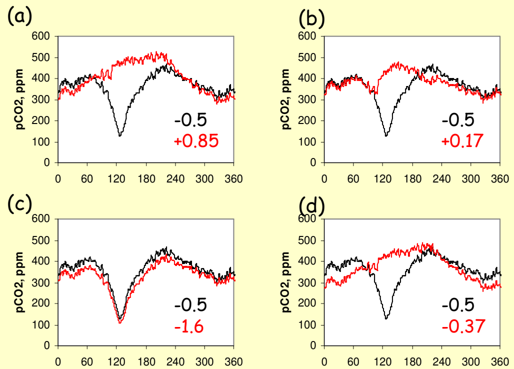
- The predicted pCO2 values show a seasonal amplitude of 340 µatm (g).
- Up to end-February, pCO2 is predicted to vary with temperature (e,g).
- A drammatic pCO2 decrease is shown in Early March at the time of diatom blooms onset (a,g) and reaches its minimum (130 µatm) at the time of Phaeocystis bloom (b,g).
- At Phaeocystis decline, pCO2 increases due to heterotrophic activity (c,d,g) and elevated temperature (d,g)
- The air-water fluxes computed at the station 330 suggests that the BCZ is a net sink for atmospheric CO2 (0.5 molC m-2 y-1).

OPEN OCEAN (WCH) vs COASTAL WATERS (BCZ)



Comparing the seasonal cycle of pCO2 predicted for the open waters (WCH) and nutrient and DIC-enriched coastal waters (BCZ) clearly shows the complex effect of nutrient-enhanced biology and DIC inputs on the carbon balance. Indeed in spite of a low net autotrophic production, the open ocean constitutes a larger sink for atmospheric CO2 than coastal waters.

PROCESSES STUDY



The relative contribution of river inputs, biological and thermodynamic processes on the CO2 budget was explored by running MIRO-CO2 by closing separately biology (a), *Phaeocystis* (b) or river inputs(c) and both biology and rivers (d).

- Nutrient enhanced primary production (a) and mostly Phaeocystis (a,b) is responsible of the negative sign of CO2 budget. It contributes to a sink of 1.35 molC m-2 y-1, *Phaeocystis* bloom account for the half of this value. Suppressing biology clearly predicts a source of CO2 (a,b)
- River DIC inputs represent an important source (1.1 molC m-2 y-1) for atmospheric CO2 but have no influence on the seasonal evolution of pCO2 (c).
- (d) During winter and fall, when biological activities are minimum, water temperature drives pCO2 variation and results in weak source for atmospheric CO2 (0.13 molC m-2 y-1).

PRELIMINARY CONCLUSIONS

The model reproduce quite well the influence of biological cycle, observed at the station 330, on the carbonate system. It also permit to quantify the impact of Phaeocystis bloom on the CO2 air-sea fluxes.

Publications:

Borges A.V. , M. Frankignoulle, 2002. Distribution and air-water exchange of carbon dioxide in the Scheldt plume off the Belgian coast. Biogeochemistry 59: 41-67.

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Lancelot C., Y. Spitz, N. Gypens, K. Ruddick, S. Becquevort, V. Rousseau, G. Billen. Modelling diatom-*Phaeocystis* blooms and nutrient cycles in the Southern Bight of the North Sea with focus on the Belgian coastal zone: the MIRO model. (submitted)